







Research Article



Feedstuffs and Feed Supplements Used for Ruminants in Benin

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ABSTRACT

Introduction: Improving agricultural productivity requires efficient production of feed ingredients and management of available resources. The primary objective of the current study was to create a classification system and management of available ingredients for sheep and cow farmers. Additionally, the study aimed to investigate the techniques employed in production and the types of feed ingredients utilized, specifically focusing on those accessible within the local context in Benin.

Materials and methods: An open-ended questionnaire was used for this study, followed by in-person interviews. A cross-sectional survey was carried out from March to April 2023, in three poles of development agriculture (PDA), including PDA2, PDA4, and PDA5, where the government projected to develop ruminant breeding. Data were collected from 450 sheep, and cow breeders selected based on the number of their animals and the breeding experience in the three PDAs. The breeders' socio-demographic characteristics, the feed supplementation practice, and the available feed resources were recorded.

Results: The survey revealed that sheep and cows were bred more by men (54.67%), married people (78.57%), and illiterate individuals (64.74%). The average age of the breeders was 45.66 years. Only 9.83% received training in animal breeding, and their main activity was cropping production. Regardless of the PDA, commercial feeds were well known but rarely used by breeders due to their high cost. Some breeders used commercial feeds only in the dry season. The feed supplements included lick stones, multi-nutritional blocks, and pelleted and floury feeds. The most widely used ingredients were agricultural by-products (cereals and legumes) and agro-industrial by-products (maize bran, cottonseed cake, and palm kernel cake).

Conclusion: The current study's findings have indicated a wide range of feed resources, such as agricultural and agro-industrial by-products in Benin, that can be exploited to produce efficient local feed supplements.

1. Introduction

Feeding the world's population is an ongoing challenge that puts considerable pressure on natural resources due to the population growth^{1,2}. Livestock has an indispensable role in solving this problem. In addition to providing proteins for consumers and constituting a source of income for producers, livestock contributes to biodiversity conservation through sustainable agriculture³. Moreover, the provided revenue by livestock enables rural breeders to fulfill their daily needs^{4,5}.

The national institute of statistics and demography has reported that meat products were among the top five imports into Benin in 2021, with 115,808.6 tons, at a value

of 59,667.7 billion CFA (basic monetary unit of West francophone African countries)⁶. National meat production was estimated at 75,866 tons in 2017⁷ or 50.86% of national consumption. Therefore, the national protein consumption level is 12 kg/capita/year, less than the minimum consumption level of 20 kg/capita/year recommended by the Food and Agriculture Organization (FAO)⁸. The unavailability of affordable animal products, particularly meat, and milk is largely responsible for the high prevalence of malnutrition⁹.

One of the factors contributing to malnutrition is the low productivity of Benin's animals, especially ruminants,

which constitute more than 68.454% (53.71% for cattle, 7.01% for sheep, and 7.72% for goats) of all meat consumption⁷. The low productivity is also closely related to ruminant breeding, which relies heavily on natural pastures and crop residues^{10,11}. However, such resources are unavailable in the dry season or have low feed values^{12,13}. These are the main reasons to import a large proportion of Benin's meat products, particularly ruminants^{6,14}. The high rate of importing meat products causes a dramatic increase in production costs of breeding farms¹⁵.

To remedy the situation, more meat products should be available. The judicious use of local resources to develop efficient local feed supplements could increase herds' productivity and survival during the dry season without decreasing production^{16,17}.

Therefore, using local ingredients to develop efficient feed supplements is a scientific as well as a political and socio-economic measure for Benin and other West African countries^{18,19}. The study aimed to investigate the techniques employed in production and the types of feed ingredients utilized, specifically focusing on those accessible within the local context in Benin.

2. Materials and Methods

The experimental design and procedures used in the present study were supervised and approved by the Animal Ethics Committee of the University of Abomey-Calavi in Benin (PFCR3/CS/UAC/CAPA). Moreover, Benin's School of Science and Technique of Animal Production reviewed and approved the study.

2.1. Location and sampling

The current cross-sectional survey was conducted to identify the socio-demographic characteristics of sheep and cattle breeders, the feed supplements used in Benin, and the ingredients that could be used to develop efficient local feed supplements. The study investigated three poles of development agriculture (PDA2, PDA4, and PDA5) in Benin (Table 1). The PDA2 covers the main cotton area of Benin, where the Government of Benin planned to integrate intensive cattle, sheep, goat, and poultry breeding and develop dairy production under act number Décret N° 2017-101²⁰. A cotton and cashew diversification zone where the Benin government planned to intensify cattle, sheep, goat, and poultry production is PDA4. The PDA5 involves a diversification zone for fruits and crops and a zone for transhumant herds (that follow a seasonal migration pattern, moving from one grazing area to another in search of food and water). It requires bold measures to manage the agro-salvo-pastoral space²⁰.

2.2. Data collection

Data collection was preceded by a focus group survey among herders, butchers, members of the transhumance

Table 1. Distribution of respondents in the survey carried out from 2023 in Benin

PDA	Communes	respondents (Number)
PDA2	Gogounou	33
	Kandi	30
	Kérou	33
	Kouandé	30
	Pehunco	24
PDA4	Bantè	28
	Djidja	28
	Glazoué	33
	N'Dali	30
	Parakou	33
	Savè	28
PDA5	Bohicon	28
	Klouékanmey	32
	Lalo	30
	Zogbodomey	30
Total		450

PDA: Poles of development agriculture

management committee, sheep and cattle merchants, rural development officials, and animal production and health agents from March to April 2023. These discussions provided information on the importance of sheep and cattle farming and feeding methods. An open-ended exploratory survey randomly identified 60 people in each PDA that determined the proportion p of sheep or cattle breeders. The number n of respondents was calculated using Dagnelie's²¹ formula as follows:

$$n = U_{0.975}^2 * p(1-p) / d^2$$

Where, n is the number of respondents for a given PDA, p denotes the proportion of PDA individuals raising ruminants, $U_{0.975}^2 \approx 1.96$ signifies the quantile of a standard normal distribution for a probability value of 0.05, and d defines the marginal error, set at 8%.

Hence, a total of 450 people were subjected to individual semi-structured interviews. The experimental data was collected with smartphones using a questionnaire digitized in Open Data Kit collect software(USA)²². The collected data were related to the socio-demographic characteristics of the farmers (age, sex, level of education, ethnicity, religion, household size, marital status, and occupation), the number of Livestock, the feed resources used to feed the animals in each season, the feed supplements, and the production objectives.

2.3. Study area

The areas and the people involved during the census are summarized in Table 1 and Figure 1. The PDA4 had the largest number of breeders ($n = 180$). There were more cattle and sheep breeders in Glazoué and Parakou than in other areas in that pole. In PDA2, Gogounou and Kérou recorded the highest number of cattle and sheep

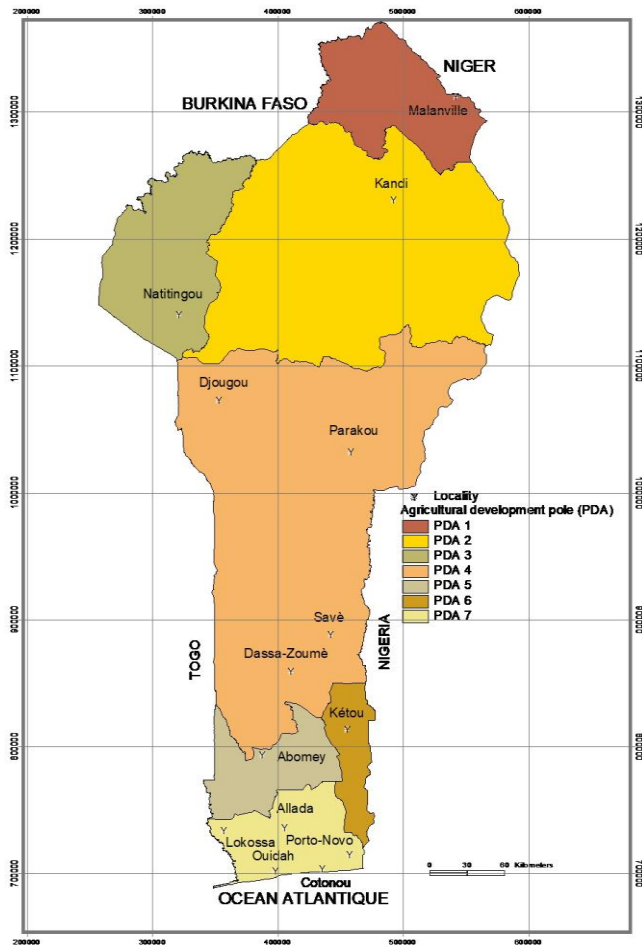


Figure 1. Poles of agricultural development in Bénin including PDA2(yellow), PDA4(orange), and PDA5(grey) in 2023. PDA: Pole developed agriculture

breeders, while Pehunco recorded the least. Regarding PDA5, the highest number of cattle and sheep breeders were recorded in Klouékanmey, whereas Bohicon had the fewest.

2.4. Data analysis

Descriptive statistics were used to analyze data on socio-demographic characteristics, feeding, and the types of feedstuffs. Analysis was performed by R software (version 4.1.1)²³. The results are reported in mean \pm standard deviation (SD).

3. Results

3.1. Socio-demographic characteristics of respondents

Table 2 presents the socio-demographic characteristics of the farmers surveyed. Cattle and sheep bred by men (54.67 ± 4.67) more than women. The imbalance in number between men and women was noticeable in PDA4.

The average age of the head of the households surveyed was around 45 years. The oldest household heads belonged to PDA5. The ethnic group of the breeders varied across the PDAs. In PDA2, the cattle and sheep breeders were primarily members of the Peulh ethnic group, and no one was from the Adja ethnic group. In PDA4, the Yoruba ethnic group was the most dominant ethnic group and Adja presented no breeder. In PDA5, almost all breeders came from the Fon (59.20%) and Adja (40%) ethnic groups. The average household size of the breeders surveyed was around eight children. The greatest average registering household size belonged to PDA2 (9.44 ± 0.52).

Table 2. Socio-demographic characteristics of respondents in the survey carried out 2023 in Benin

Items (%)	Variables			
Sex	Male	57.45	49.75	56.8
	Female	42.55	50.25	43.2
Age	Mean \pm SD	44.62 \pm 1.06	45.43 \pm 0.90	46.92 \pm 1.31
Ethnicity	Adja	0.00	0.50	40.00
	Bariba	34.04	16.92	0.00
	Fon	0.71	24.38	59.20
	Peulh	51.77	8.46	0.00
	Yoruba	4.96	43.78	0.8
	Others	8.51	5.98	0
Household size	Mean \pm SD	9.44 \pm 0.52	8.39 \pm 0.48	7.38 \pm 0.42
Religion	Christian	14.89	71.15	56
	Muslim	84.4	23.88	2.4
	Traditional	0.71	4.98	41.6
Marital status	Single	2.84	3.98	1.6
	Married	91.49	90.05	80
	Widowed	5.67	5.97	18.4
Educational level	Literate in French	2.13	0.50	1.6
	Literate in national language	0.71	4.48	2.4
	No schooling	83.69	53.73	56.8
	Primary	3.55	15.42	14.4
	Secondary	8.51	23.88	24
Training in breeding	University	1.42	1.99	0.8
	Yes	2.84	7.46	19.2
	No	97.16	92.54	80.8

SD: Standard deviation, PDA: Pole of agricultural development

Regarding the religious affiliation of the breeders, apart from PDA2, where the Muslims were dominant (84.4%), the breeders in the other two PDAs were more represented by Christians (71.15% and 56% in PDA 4 and PDA5, respectively). Most breeders were married ($87.18 \pm 6.25\%$); however, PDA5 had fewer married respondents and more widowed ones (18.4%). The majority of the breeders were illiterate in all three PDAs, but the situation was especially critical in PDA2 (83.69% unschooled versus 57.73% and 56.8% for PDA4 and PDA5, respectively). More than 90% of the breeders have not received professional animal breeding training; however, there were more trained breeders in PDA5 (19.2%), compared to PDA2 and PDA4.

3.2. Main activities of respondents

Figure 2 shows that most of the farmers surveyed, regardless of the PDA, were involved in crop production and the situation seems more balanced in PDA4. Most breeders

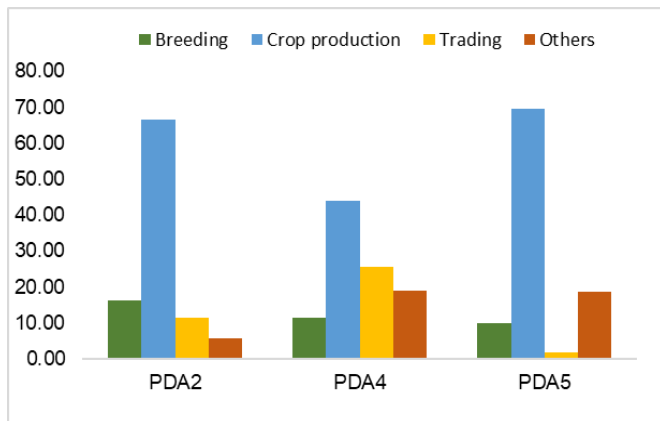


Figure 2. Main activities of the large animal breeders in Benin during 2023

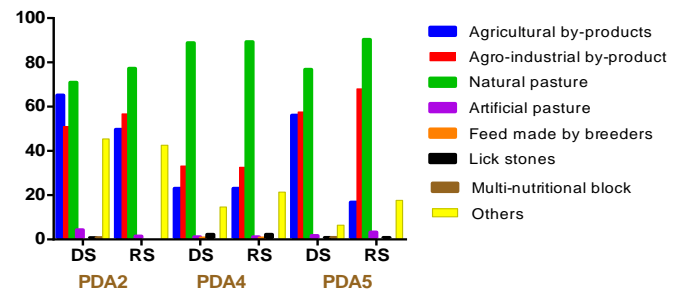
were involved in crop production in PDA5 than other poles.

Regarding PDA4, breeding was the least practiced profession. The number of traders in PDA4 was more than PDA2 and PDA5. Considering PDA5, breeding had the third position after crop production and other activities.

followed by agricultural by-products and agro-industrial by-products. The results also indicated a shallow use of conventional feed supplements (lick stones and multi-nutritional block) in all PDAs.

3.3 Feeding: types of feed resources and feed supplements used in each PDA

Figure 3 presents the types of feed resources and supplements used in each PDA. From this information, it can be noted that natural pasture is the most exploited regardless of the PDA and seasons, followed by agricultural by-products and agro-industrial by-products. The results also indicate a shallow use of conventional feed supplements (lick stones, multi-nutritional block) in all PDAs.



DS: Dry season, RS: Rainy season, PDA: Agricultural development pole
Figure 3. Types of feed resources and supplements used in each PDA

Table 3. Feedstuffs available in each pole of agricultural development in Benin during 2023

Agricultural Development Pole (PDA)	Local feedstuffs	Availability	
		Rainy season	Dry season
PDA2: Alibori Sud - Borgou Nord- 2KP (Kandi, Banikoara, Segbana, Gogounou, Kouandé, Kérou, Pehunco, Sinendé, Kalalé, and Bembéréké)	Sown pasture	+++	++
	Cassava peels	+++	+++
	Yam peels	++	+++
	Maize meal	++	+++
	Maize	++	+++
	Maize food	++	++
	Kitchen waste	++	++
	Residue of milling	++	++
	Common salt	++	++
	Maize bran	++	+++
	Wheat bran	+++	+++
	Soybean bran	++	+++
	Sorghum bran	+++	+++
	Cottonseed cake	+++	+++
	Soybean meal	++	+++
	Cowpea powder	++	++
	Cowpea pod husk	+	++
	Soybean hulls	++	++
	Sorghum hulls	++	+++
	Sorghum stalks	++	+++
	Cocoa pods	+	+
	Shea butter cake	+++	+++
	Sorghum brewer's grain	+++	+++
	Soybeans	++	+++
	Peanut hulls	++	+++
	Peanut skins	++	+++

Table 3. Continued

PDA4: Borgou Sud-Donga - Collines (Tchaourou, Parakou, N'Dali, Nikki, Pèrèrè, Djidja, Savalou, Bantè, Das sa-Zoumè, Clazoué, Savè, Ouèssè, Djougou, Ouaké, Bassila, and Copargo)	Cassava peels	+++	+++
	Mango leaves	+++	++
	Food waste	++	+
	Maize bran	++	+++
	Wheat bran	+	++
	Soybean bran	++	+++
	Soybean meal	++	+++
	Rice bran	+++	+++
	Cowpea bran	++	+++
	Potato peels	++	+++
	Cassava meal	+++	+++
	Rice hulls	+++	+++
	Sorghum brewer's grain	+++	+++
	Peanut cake	++	++
	Cowpea hulls	++	++
	Yam peels	+++	++
	Cottonseed cake	++	+++
	Tchoukoutou brewer	++	++
	Peanut hulls	+	+++
	Maize food	++	++
PDA5: Zou-Couffo (Covè, Zangnanando, Ouini, Za-Kpota, Zogbodomey, Bohicon, Abomey, Agbangnizoun, Dogbo, Aplahoué, Toviklin, Lalo, Klouékanme, and Djakotomey)	Kitchen waste	+	++
	Palm leaves	+++	++
	Maize	++	+++
	Maize bran	++	++
	Maize stalk	+	+++
	Soy bran	+	++
	Peanut hulls	++	++
	Peanut skins	++	++
	Cassava meal	++	++
	Cassava peels	++	+++
	Orange peels	+++	+++
	Rice bran	++	++
	Palm kernel cake	+	+
	Pigeon pea skins	++	++
	Pigeon pea stalks and leaves	++	++
	Rough rice (paddy)	+	++
	Cassava leaves cooked	+++	++
	Cassava leaves	+++	++
	Cowpea hulls	+	+++
	Orange	+++	+++
	Old cocoyam peels	++	++
	Cowpea bran	+	++
	Banana peels	+	+
	Papaya peels	++	++
	Breadfruit peels	++	++
	Ananas peels	+++	+++
	Yam peels	+	+
	Old cocoyam hulls	+	+
	<i>Irvengia gabonensis</i> fruit peels	+	++
	<i>Irvengia gabonensis</i> fruit	+	++
	Copra cake	+++	+++

+++ : Available in great quantity, ++ : Available in acceptable quantity, + : Available in low quantity

3.4. Available feedstuffs in the survey

Table 3 reveals the local feedstuffs available in each pole of agricultural development and their level of availability in each season. Regardless of the season, cassava peels, wheat bran, sorghum bran, cottonseed cake, shea butter cake, and sorghum brewer's grain were greatly available in PDA2. In addition, feedstuffs, such as yam peels, maize meal, maize, soybean bran, soybean meal, sorghum hulls, stalk, soybean, peanut hulls, and peanut skins were widely available during the dry season when pasture is not available. In PDA4, cassava peels, rice bran, cassava meal, rice hulls, and sorghum brewer were greatly available regardless of the season. Furthermore, maize bran, soybean bran, soybean

meal, cowpea bran, potato peels, and cottonseed cake were generally functional in the dry season when pasture was impossible. Regardless of the season, orange peels, ananas peels, and copra cake were widely available in PDA5. In addition, maize, maize stalk, cassava peels, and cowpea hulls were generally available in the dry season.

3.5. Types of the production system

The survey identified two breeding systems of traditional (figures 4 and 5) and semi-modern (Figure 6). Two variants characterized the traditional system. Traditional grazing (Figure 4), where animals were left by themselves and just tied with rope to a tree in the rainy



Figure 4. Traditional system with grazing in Benin 2023

season to prevent their entrance to the crop farm around the habitation, and the traditional improved system (Figure 5), where animals had a kind of sheepfold but made with improved building materials. Breeders provided the animals with local feedstuffs, such as maize bran, cassava peels, and kitchen waste. In the semi-modern system, the animals had improved sheepfold and



Figure 5. Improvement of the traditional system in Benin 2023

a building with stable materials. The breeders in the semi-modern system tried to provide the animals with some feed supplements, such as lick stones or multi-nutritional blocks, bought from the local market (Figure 6).



Figure 6. Semi-modern system in Benin during 2023

4. Discussion

The results showed that men led most of the households surveyed. This may be an asset in implementing improved livestock systems, given that men decide on resource management in most homes in Benin²⁴. This tendency is more noticeable in PDA2, in the northern part of Benin, since this part of the country is still heavily influenced by traditional perceptions of society, and men are considered family leaders. Both PDA4 and PDA5 are close to urban areas and are more strongly influenced by the modern perception of society²⁵.

The results also revealed that most breeders were married regardless of the PDA. Accordingly, most herders were responsible, but the requirement to care for large households was probably one reason for the low investment in livestock²⁶. Most breeders in PDA2 came from the Peulh ethnicity group. As the Peulh have breeding as part of their culture, it could be easy to supplement feed in this geographic area^{27,28}. Most breeders in PDA2 were Muslim, so they use sheep and cattle for many religious ceremonies²⁹. The ease of breeding small ruminants, compared to larger breeds and the market demand, also justify this observation.

Regardless of the PDA, most breeders were illiterate and had no professional animal breeding training. People of Benin generally believe that agriculture is inappropriate for educated people^{27,30}. The high illiteracy rate affects the production system as the breeders do not use prescribed veterinary products³¹. The lack of basic training in animal husbandry among breeders explains the poor performance often recorded and the low contribution of Livestock to Benin's gross domestic product (GDP)^{6,32}. Training would give them at least the rudimentary knowledge necessary for effective livestock management.

Regardless of the PDA, crop production appeared to be the main activity. This is an advantage for the availability of crop residues that can be used as animal feed³³. However, this fact also may explain why animals are sometimes neglected, since more attention is paid to crop farming. Nevertheless, as human habitation occupies more area and reduces the crop farming areas, more attention may be given to breeding, which is sometimes used by the breeders as a credit, especially in difficult periods⁴.

Regardless of the PDA, some potentially nutrient-rich feedstuffs are available that could increase breeders' productivity. These resources may be helpful in manufacturing and implementing efficient feed supplements across Benin³⁴. The success of such an undertaking would require the stabilization of resources, especially seasonal feed supplements³⁵. The results confirm the data collected by FAO³⁵ and allow to reconsider a decision about developing ruminant livestock in the country.

The current study has revealed that the breeding system needs to be improved if the country wants to enhance the breeding of the ruminants as the government

desires it²⁰. Achieving this goal requires using feed supplements, especially in the dry season when natural pasture, as the primary feed in each PDA is unavailable. Feed supplements become compulsory even in the rainy season as most natural ranges are destroyed due to the demand for natural resources^{36,37}. According to the government which intends to develop the breeding industry in the PDAs, wise management of feed resources through the manufacture of efficient feed supplements seems necessary²⁰. It is in line with an argument by FAO in favor of agricultural products³⁵.

5. Conclusion

This study explored the socio-demographic characteristics of the ruminant breeders, the feed resources available in each season, the types of used breeding systems, and the feeding management of sheep and cattle in the study area. Most of the breeders were illiterate, and more than 90% of the breeders had not received professional animal breeding training. Regardless of the season, a diverse range of feed resources with significant nutritional value is available in each PDA. However, weak management in the rainy season impairs abundant resources and the agro-industrial by-products, putting animals in a difficult situation, especially in the dry season. Poor knowledge about ingredients' nutritional value often limits their rational use. Although the conversion of feedstuffs into stable feed supplements, such as lick stones, multi-nutritional blocks, and pellet feed, which will result in efficient production regardless of the season, maybe often difficult for local farmers. It is then necessary for Benin to promote local enterprises that can transform the local feedstuffs into efficient and stable feed supplements at each pole of agricultural development.

Declarations

Competing interests

The authors have declared that no competing interests exist.

Authors' contributions

This work was carried out in collaboration with the following authors. Faustin DOKUI. and Frédéric M. HOUNDONUGBO designed and coordinated data collection. Faustin DOKUI wrote the protocol, performed the analysis, managed the study analyses, and wrote the first draft. Christophe. A. A. M. CHRYSOTOME and Séverin BABATOUNDE participated in study design and planning and reviewed the manuscript. All authors read and approved the final manuscript draft.

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Availability of data and materials

Data and Materials used are available per request.

Ethical considerations

Ethical issues, such as data fabrication, double publication and submission, redundancy, plagiarism, consent to publish, and misconduct, have been checked by all the authors before publication in this journal.

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